FOSSILIFEROUS LOWER DEVONIAN BOULDERS IN CRETACEOUS SEDIMENTS OF THE GREAT AUSTRALIAN BASIN

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Summary

FLINT, R. B., AMBROSE, G. J. & CAMPBELL, K. S. W. (1980) Fossiliferous Lower Devonian boulders in Cretaceous sediments of the Great Australian Basin. *Trans. R. Soc. S. Aust.* **104**(3), 57-65, 30 May, 1980.

During 1977-78, 32 fossiliferous Lower Devonian quartzite boulders were discovered within Mesozoic sediments along the southwestern margin of the Great Australian Basin. Previously only two such specimens had been discovered in South Australia though similar occurrences have been known in New South Wales since 1898. Fossils not previously recorded in S.A. include the fish *Wuttagoonaspis*, the brachiopods *Howellella jaqueti* and *Sphaerirhynchia* sp.; the bivalves *Leptodesma inflatum*, *Sanguinolites* sp. and *Praectenodonta* sp.; the gastropod *Straparollus culleni;* and abundant tentaculitids. Similar fossiliferous Devonian rocks are not known *in situ* in S.A. The probable source area is the fossiliferous Amphitheatre and Mulga Downs Groups near Cobar in N.S.W. It is suggested that boulders were transported to S.A. during the Permian glaciation and then reworked into Cretaceous bouldery shales and sands. All but two of the boulders are found within conglomeratic sediments at the base of the Bulldog Shale. Theories on transport processes during the Cretaceous are discussed; it is concluded that conglomeratic sediments at the base of the Bulldog Shale are reworked submarine debris-flow deposits.

Introduction

Fossiliferous Devonian quartzite boulders from Cretaceous sediments were first described from White Cliffs Opalfield in N.S.W. by Dun (1898). P. J. Russ collected the first fossiliferous boulder in S.A. in 1966 from an opal shaft at the Andamooka Opalfield. It was thought at the time that an opal miner may have brought the boulder to S.A. from White Cliffs. However, after discovery of a second fossiliferous boulder near Dalhousie Springs by M. C. Benbow, the geological implications were assessed by Campbell *et al.* (1977). They concluded that the fossiliferous boulders, like those at White Cliffs, were derived from the Devonian Amphitheatre Group near Cobar in N.S.W., and that they were transported to S.A. during the Permian glaciation, later to be reworked into Cretaceous strata.

During geological mapping of the BILLA KALINA 1:250 000 map sheet and subsequent investigations elsewhere along the margin of the Great Australian Basin, a further 32 fossiliferous boulders were discovered, containing many species not previously recorded in S.A. Their occurrence and distribution permit a new assessment of their probable origin and modes of transport. The earlier concept of Campbell *et al.* (1977) is substantiated.

Geological setting

Stratigraphic units in the southwestern Great Australian Basin include the Algebuckina Sandstone, Cadna-owie Formation and Mount Anna Sandstone Member, Bulldog Shale and overlying younger Mesozoic sediments (Fig 1). The stratigraphic nomenclature adopted here is that of Wopfner *et al.* (1970) based on the Oodnadatta-William Creek area (for the Marree area see Forbes 1966).

The following geological summary is compiled from Wopfner & Heath (1963), Ludbrook (1966, 1978), Wopfner *et al.* (1970), Morgan (1977), Carr *et al.* (1978)[1], Pitt (1978), Vnuk (1978)[2] and from observations during geological mapping of the BILLA KALINA 1:250 000 map sheet.

The Upper Jurassic Algebuckina Sandstone consists of fine to medium-grained sandstones and kaolinitic, conglomeratic sandstone. Clasts within the conglomeratic sandstones are chiefly

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[1] Carr, S. G., Olliver, J. G., Conor, C. H. H. & Scott D. C. (1978) Andamooka Opal fields: The geology of the precious stones field and the result of the subsidised mining programme S. Aust. Dept Mines & Energy Rept 78/5 (unpublished).

[2] Vnuk, M. F. (1978) Aspects of the geology of the Stuart Creek area, north of Lake Torrens, South Australia. B.Sc. (Hons.) thesis, University of Adelaide (unpublished).

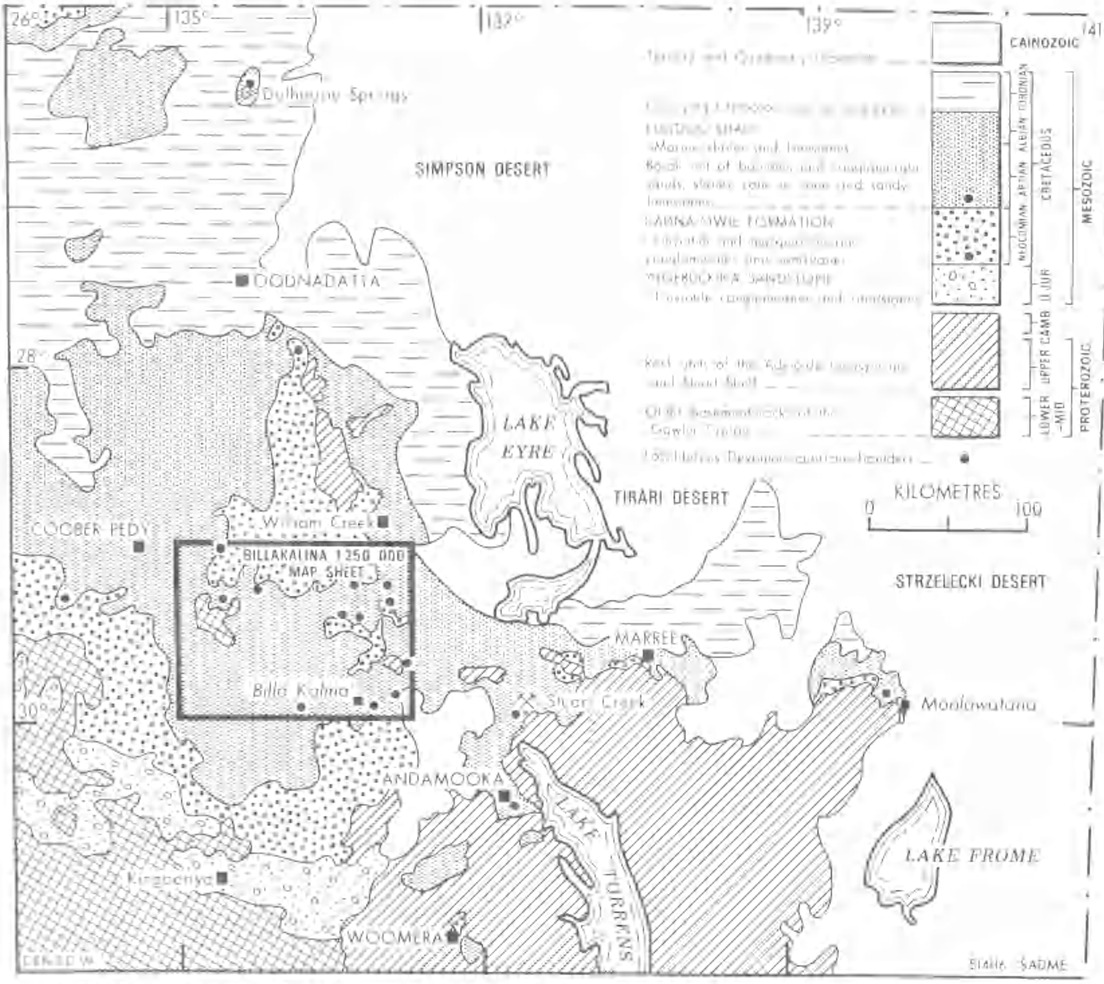


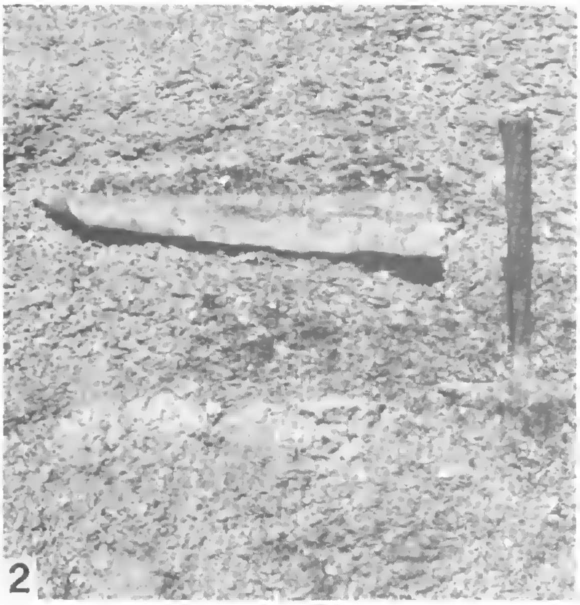
Fig. 1. Geological map of southwestern margin of Great Australian Basin, modified from Thomson (1980). All known localities of fossiliferous Devonian quartzite boulders in S.A. shown.

rounded to well-rounded white quartz pebbles. However, weathered acid porphyry and quartzite pebbles and cobbles are also common. The unit was deposited in a low gradient, fluviatile environment.

Transgression in the Neocomian led to the disconformably overlying Cadna-owie Formation, consisting of marginal marine very fine to medium-grained, micaceous and occasionally conglomeratic sandstones. Clasts within the sandstones are chiefly pebble, cobble and boulder-sized quartzites up to 1 x 1 x 0.5 m. Later in the Neocomian, partial regression led to the deposition of the coarser Mount Anna Sandstone which consists of medium to coarse-grained, feldspathic and conglomeratic sandstones and micaceous sandstones. Clasts of porphyritic acid volcanics characterise the conglomeratic sandstones, though white quartz and quartzite clasts are also common. The clasts are sub-rounded to well-rounded and in the size range 0.02-0.2 m. Concave and festoon cross bedding are ubiquitous; foresets are up to 2 m high and bedding within the foresets is graded.

The second Cretaceous marine transgression, in Aptian time, was of much greater extent and resulted in marine shale deposition (Bulldog Shale) over a large area of the Great Australian Basin. Basal lithologies of the Bulldog Shale range from bouldery to conglomeratic sand to grey shales, cone-in-cone limestones and sandy limestone. Fossil tree trunks are common. Clasts within the conglomeratic sediment are predominantly quartzites with minor acid porphyries and banded chalcedony, and occur in either bioturbated grey shales or thin coarse-grained sand lenses (Fig. 2). The sand lenses vary from only a few centimetres thick to massive lenses up to a metre thick with boulders scattered in the sandy matrix (Fig. 3). These sediments interfinger with and are overlain by bioturbated dark grey shales and silts, and fossiliferous limestones. A subsequent regression and a further two transgressive-regressive cycles occurred in the Albian to Turonian.

The fossiliferous Devonian quartzite boulder from the locality southeast of Oodnadatta is the only specimen weathered out from mar-



Figs 2-5. 2, Unfossiliferous quartzite boulder within bioturbated marine shales of Cretaceous Bulldog Shale, 60 km north of "Billa Kalina"; 3, Rounded quartzite cobbles near top of coarse-grained sand lens, and overlying bioturbated marine shales (Bulldog Shale) from 20 km east of Billa Kalina locality 1; 4, Well-rounded quartzite boulder lag near Billa Kalina locality 2. Many boulders are fractured due to Holocene weathering; 5, Surface gibber lag east of Coober Pedy: cobbles and boulders derived from basal sediments of Bulldog Shale. Clasts are dominantly quartzites; less than 1% contain Devonian fossils.

ginal marine sediments of the Cadna-owie Formation. All other fossiliferous boulders (including the original two specimens discovered at Dalhousie Springs and Andamooka, and previously thought to be derived from the Cadna-owie Formation) have weathered out from basal conglomeratic sediments of the Bulldog Shale.

Description of the boulders

Basal conglomeratic sediments of the Bulldog Shale crop out poorly but erosion has resulted in numerous clasts from the conglomerates, ranging in size from pebbles to boulders, forming a lag on the present day land surface (Figs 4, 5). Physically-resistant clast types dominate, mostly quartzites (feldspathic and/or lithic), with minor porphyritic acid volcanics and whitish-grey banded chalcedony. Granite, gneiss, quartz and shale clasts are rare, but may be locally more common near Proterozoic outcrops.

A high proportion of the quartzite boulders have abundant clay pellet impressions, a feature typical of the Upper Proterozoic Arcoona Quartzite on the Stuart Shelf. The porphyritic acid volcanics are similar to the Middle Proterozoic Gawler Range Volcanics on the Gawler Craton (Wopfner *et al.* 1970), while banded chalcedony clasts are similar to cherts and siliceous concretions in the Cambrian Andamooka Limestone.

Less than 1% of all boulders contain Devonian fossils. The fossiliferous boulders are siliceous, feldspathic and lithic quartzites. They consist of quartz-rich, medium-grained sand (0.2-0.3 mm) and minor (<10%) potash feldspar grains cemented by secondary quartz overgrowths. The lithic quartzites contain small fragments of sericitic schists and acid porphyries (Whitehead 1978)[8]. It is not possible to distinguish lithologically between fossiliferous Devonian quartzites and other quartzite clasts.

Faunas of the boulders

In the two fossiliferous Devonian boulders previously recorded in South Australia (Campbell *et al.* 1977), the specimen from Dalhousie Springs contained the brachiopod *Howellella jaqueti* (Dun) and bivalve *Actinopteria* sp.; these were also present in the specimen collected from Andamooka. In the latter sample tentaculitids and brachiopod *Isorthis* sp. were also present. The fossils found in the boulders during 1977-78 are documented below, and include many species not recorded previously in the boulders. All specimen numbers refer to the fossil collection of the Geological Survey of South Australia.

Billa Kalina locality 1 (lat. 29°28'10"S, long. 136°08'00"E) — Specimen numbers 6139 RS 29-34, 39.
- Fish plate: *Wuttagoonaspis* sp. (Fig. 6)
- Brachiopods: *Howellella jaqueti* (Dun)
  - Brachiopoda indet.
- Bivalves: *Leptodesma inflatum* (Dun)
  - Bivalvia indet.
- Tentaculitid: *Tentaculites* sp. (Fig. 7)

Billa Kalina locality 2 (lat. 29°28'00"S, long. 136°06'50"E) — Specimen numbers 6139 RS 35-36.
- Brachiopod: *Howellella jaqueti* (Dun)

Billa Kalina locality 3 (lat. 29°58'20"S, long. 136°12'50"E) — Specimen numbers 6138 RS 74-77
- Brachiopoda indet.
- Bivalvia indet.
- Fish plates and spines

Billa Kalina locality 4 (lat. 29°57'30"S, long. 136°18'35"E) — Specimen numbers 6138 RS 78-85.
- Brachiopods: *Howellella jaqueti* (Dun)
  - Brachiopoda indet.
- Bivalves: *Sanguinolites* sp.
  - Bivalvia indet.
- Gastropods: *Straparollus culleni* (Dun) (Fig. 8)
  - *Holopea* sp.
  - Murchisoniidae indet.
- Echinodermata indet.
- Fish Plates and spines

Billa Kalina locality 5 (lat. 29°11'00"S, long. 136°21'05"E) — Specimen number 6139 RS 37
- Tentaculitid: *Tentaculites* sp.
- Crinoid ossicles
- Bryozoa indet.

Billa Kalina locality 6 (lat. 29°12'15"S, long. 136°09'05"E) — Specimen number 6139 RS 38.
- Bivalve: Bivalve indet.
- Crinoid ossicles

Billa Kalina locality 7 (lat. 29°02'05"S, long. 135°12'20"E) — Specimen number 5939 RS 92.
- Brachiopod: Brachiopoda indet.
- Crinoid ossicles

Billa Kalina locality 8 (lat. 29°55'00"S, long. 135°49'30"E) — Specimen numbers 6038 RS 12-13.
- Brachiopods: Stropheodontid (probably *Mesodouvillina* or *Mclearnites*) (Fig. 9)
  - Brachiopoda indet.

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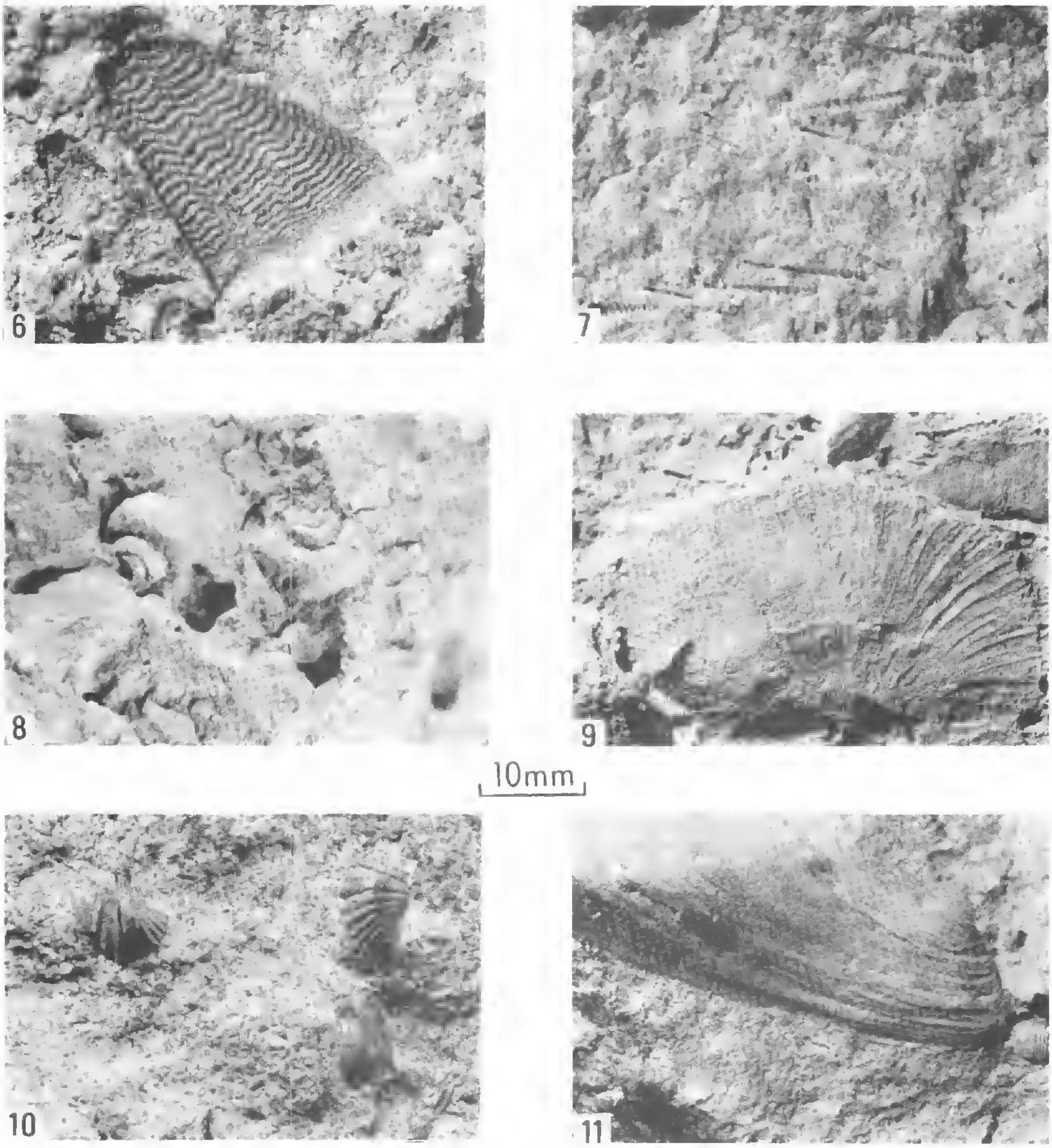
[8] Whitehead, S. (1978) Description of quartzite boulders. Amdel Rept. No. GS 415/79 (unpublished).

Tentaculitid: *Tentaculites* sp.
Crinoid fragments
Bryozoa indet.

Moolawatana (lat. 20°52′12″S, long. 139°38′00″E) — Specimen numbers 6838 RS 129-132.

Brachiopods: *Howellella jaqueti* (Dun) (Fig. 10)
Brachiopoda indet.
Bivalves: *Leptodesma inflatum* (Dun)
Bivalvia indet.
Tentaculitid: *Tentaculites* sp.



Figs 6-11. 6, External impression of unidentified plate of *Wuttagoonaspis*, specimen 6139 RS 39 from Billa Kalina locality 1; 7, Numerous aligned external moulds of *Tentaculites* sp., specimen 6139 RS 32 from Billa Kalina locality 1; 8, Two internal moulds *Straparollus culleni* (Dun), sample 6138 RS 79 from Billa Kalina locality 4; 9, External mould of pedicle valve of stropheodontid brachiopod (*Mesodouvillina* or *Mclearnites*), sample 6038 RS 12 from Billa Kalina locality 8; 10, Internal moulds of pedicle and brachial valve of *Howellella jaqueti* (Dun), specimen 6838 RS 129 from "Moolawatana" locality; 11, External mould of *Sanguinolites* sp. from Stuarts Creek locality, specimen 6337 RS 21.

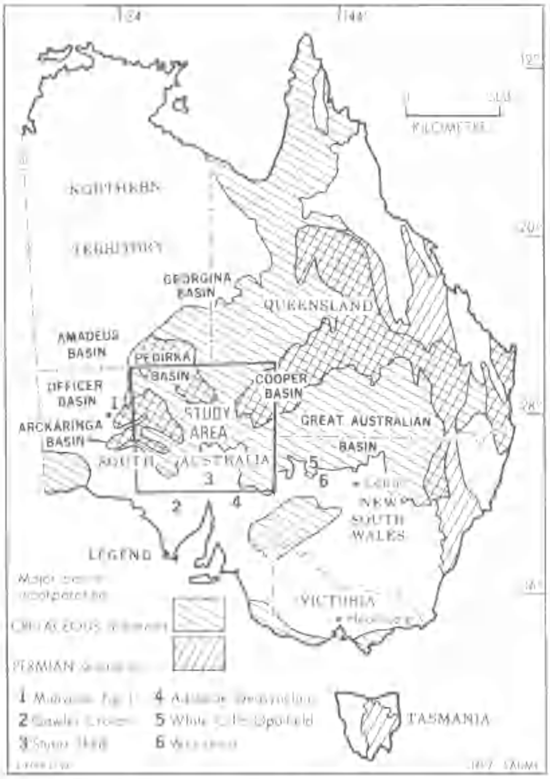


Fig. 12. Locality plan showing distribution of basins incorporating Cretaceous and Permian sediments in central and eastern Australia.

Oodnadatta (lat. 27°55'30"S, long. 135°46'40"E) — Specimen numbers 6042 RS 92-93.
Bivalve: *Praectenodonta* sp.
Tentaculitid: *Tentaculites* sp.

Stuarts Creek (lat. 30°05'45"S, long. 137°11'30"E) — Specimen numbers 6337 RS 21-34.
Brachiopods: *Sphaerirhynchia* sp.
Howellella jaqueti (Dun)
Bivalves: *Sanguinolites* sp. (Fig. 11)
Tentaculitid: *Tentaculites* sp.
Crinoid ossicles.

Provenance of the fossiliferous boulders

Neither the invertebrate nor the vertebrate faunas preserved in the boulders have been recorded from *in situ* Devonian sediments in basins in S.A., or the adjacent Amadeus or Georgina Basins. The only possible Devonian vertebrates known from S.A. are the fish scales from a mudstone at 817–823 m in Munyarai No. 1 within the Officer Basin (Fig. 12), but these were not positively identifiable (Gilbert-Tomlinson 1969)[1]. Devonian placoderm remains from the Amadeus and Georgina Basins are bothriolepids (Young 1974) which are not similar to the specimens from the boulders. No Devonian invertebrates are known from the above basins. However, as has been indicated previously, both the lithologies and invertebrate faunas are very similar to those from the Amphitheatre Group near Cobar in N.S.W., described by Landrum (1975), and to those from the boulders in Cretaceous sediments at White Cliffs, N.S.W., described by Dun (1898).

On the other hand, marine Lower Devonian sandstones with comparable invertebrate faunas to those at Cobar are also known from the Mt Ida Formation of central Victoria and the Eldon Group of western Tasmania. These have to be considered as alternative source areas, but there are good reasons for rejecting them. The absence of *Notoconchidium* from the boulders in S.A. is taken as evidence against either a Victorian or a Tasmanian source because this genus is relatively common in a hard quartzite in both these areas. The durability of this material is attested by the fact that *Notoconchidium* is among the more common fossils in the Lower Devonian boulders from Permian diamictites in north-eastern Victoria. A second important feature is the abundance of *Howellella jaqueti* in boulders from S.A. Although *Howellella* occurs in a variety of forms at Heathcote, Talent (1965) records that they are poorly preserved. The genus is also poorly represented in the Eldon Group. *H. jaqueti* is one of the most common species in boulders from S.A., as it is in several horizons in the Amphitheatre Group.

Although there are now many more boulders with a wider range of species than was known previously, it still is possible to match the entire invertebrate fauna with that from the Amphitheatre Group. In the absence of a complete account of the Eldon Group fauna, this evidence of itself can be no more than suggestive; but taken in conjunction with the data on *Notoconchidium* and *Howellella* given above it is more persuasive of a Cobar source.

[1] Gilbert-Tomlinson, J. (1969) Fossils from Munyarai No. 1 Well, Officer Basin, South Australia. *In* "Continental Oil Company of Australia Ltd. Munyarai No. 1, South Australia." Well completion report, S. Aust. Dept Mines & Energy env. 979 (unpublished).

Further weight is lent to this view by the discovery of fossil fish fragments in boulders at three of the Billa Kalina localities. So far as we are aware no Devonian fish beds are known from Tasmania, though they are well exposed in central and eastern Victoria and over much of central N.S.W., where they are mainly of Late Devonian age. The most important discovery is the fragment referred to *Wuttagoonaspis* Ritchie (1973) from the Mulga Downs Formation of probable Middle Devonian age in the Mt Grenfell area west of Cobar, and Mt Jack north of Wilcannia. This specimen is only an impression of a fragment of an undetermined bone, but its ornamentation is distinctive. Its identification has been confirmed by Ritchie.

We therefore conclude from the available evidence that the source for the fossiliferous boulders is in the Cobar region, the boulders having been transported at least 1000 km in a westerly to northwesterly direction.

Transport of the boulders

A palaeoenvironmental interpretation of Jurassic-Cretaceous sediments in the southwestern Great Australian Basin by Wopfner *et al.* (1970) indicates that transport of boulders in this direction and for this distance during the Mesozoic was improbable. However, Permian ice may have transported the fossiliferous boulders from the Cobar area to northern S.A., and the unconsolidated Permian diamictites could then have been reworked into Mesozoic sediments (Campbell *et al.* 1977). Thus two phases of transport would be involved.

In northern S.A., Permian diamictites are preserved in Palaeozoic basins under the Great Australian Basin (e.g. Arckaringa, Cooper and Pedirka Basins) and in small grabens within the Gawler Block. These distributions suggest that such deposits were once widespread but that they have been largely removed from uplifted areas.

Crowell & Frakes (1975) using the distribution of glacial till and fluvial sediments and palaeocurrent analysis, postulated a large Permian continental ice cap over northwestern N.S.W., with glacial debris being shed eastwards and possibly westwards into the basins of northeastern S.A. This interpretation differs from that of Wopfner (1970) who concluded that the composition of erratics in Permian diamictites of the Arckaringa Basin indicated local glaciation rather than a continental ice sheet. He suggested that Permian glaciers originated on upfaulted highland areas; glacial debris was dumped along basin margins and then transported by mudflows and turbidity currents into distal parts of the basins.

Though we prefer the views proposed by Crowell & Frakes, it must be stressed that to date no fossiliferous Devonian boulders have been discovered in Permian diamictites in S.A., ice-movement directions during the Permian are not known for northern S.A., and there are conflicting views on the Permian palaeoenvironment and likelihood of long-distance transport. Nevertheless, ice transport seems to be the only feasible means for transporting boulders from the Cobar area to northern S.A., and the Permian is the only period in the required interval for which glaciation of an appropriate magnitude has been demonstrated.

Final emplacement of the boulders

The processes by which the Cretaceous boulder beds were formed have been debated for nearly 100 years. This paper is not intended to provide a detailed discussion of the problem, but it does add another feature that requires explanation — viz. the distant provenance of some of the boulders. It has been thought appropriate that a summary of the issues should be presented.

Features requiring explanation are

(a) the scatter of boulders through a sandy or shaly matrix which is bioturbated in places;

(b) the rounded form of most of the boulders, though an occasional facetted or striated boulder has been noted (Jack 1915; Woolnough & David 1926);

(c) the predominance of quartzites among the boulders, with acid porphyries and chalcedony forming the majority of the remainder;

(d) the occurrence of fossiliferous boulders in Cretaceous rocks from White Cliffs to Dalhousie Springs.

The shape and composition of the boulders indicates the operation of processes that have removed all but the most durable materials, and that these processes were at least in part physical. Tumbling experiments by Abbott & Peterson (1978) showed chert, quartzite and rhyolite to be the most durable rock types, followed by metabreccia, obsidian, metasandstone, gneiss, 'granites', metabasalt, marble and schist. The first three rocks are also chemically resistant.

One possible source for many of the clasts is in Proterozoic/Cambrian rocks such as those of the Gawler Craton and Broken Hill Block which could provide abundant quartzite, acid porphyry (Gawler Range Volcanics) and chalcedony (Andamooka Limestone). A second source would be the Permian diamictite, mentioned above, which is known to contain clasts of limestone, schist, gneiss, granite, acid porphyry, quartzite, quartz, banded iron formation, chert and shale. The original source of many of these clasts must have been the Proterozoic/Cambrian rocks indicated above. Both the above sources would have been subjected to prolonged weathering between the Permian and the Early Cretaceous, and transport to the Cretaceous sea with subsequent shoreline deposition would have resulted in the removal of the less durable clasts.

Brown (1905), Jack (1915), Woolnough & David (1926) and Vnuk[2] considered that ice rafting was responsible for the final transport of the boulders and that they were mainly dropstones. In our view this mechanism is not acceptable. If the proposed ice was calved off from glaciers there would be no explanation for the dominance of resistant clasts, their rounded shapes, or their abundance over so large a geographical distribution. If sea ice picking up clasts from a boulder-strewn shore were proposed, it would be possible to explain the clast types and shapes, but the problems of volume and distribution would remain. In addition there is no independent evidence of glacial conditions in the Early Cretaceous, though the area in question would have been within 30° of the pole.

Woolnough & David (1926) also considered, but rejected, tree rafting as a possible transport mechanism for the boulders. Much later Wopfner *et al.* (1970) reinstated the proposal because of the abundance of fossil wood in Early Cretaceous sediments. However because of the abundance and concentration of boulders within particular horizons, tree rafting was not accepted as the sole transport mechanism. Since they considered the boulder beds to be restricted to margins of basement highs, they also proposed that the boulders originated on shorelines and migrated downslope by slow sediment creep. It is this latter suggestion that seems to us to provide a clue to a possible solution — namely that they are reworked debris-flow deposits. Bouldery debris-flow deposits typically consist of a massive fine-grained matrix with randomly dispersed boulders (Fisher 1971; Middleton & Hampton 1973; Carter 1975; Hampton 1975) but the beds under discussion are not of this type. Some other processes must have been operative in addition. We propose, therefore, that boulders, cobbles and sand were transported basinwards from a boulder-strewn shore line in a clay-rich, watery matrix over low angle slopes. The debris flows were episodic events, permitting time for some reworking of the debris-flow sediments, and subsequent shale sedimentation and bioturbation. Winnowing of muds and fine sands from the debris-flow sediments by currents, and possibly by waves, has resulted in some of the boulders and cobbles being concentrated in thin, coarse-grained sand lenses. Complete winnowing of the fines and further shale deposition has resulted in some boulders being located within bioturbated shales.

Acknowledgments

Appreciation is extended to G. Johansen (Newmont Pty Ltd), M. F. Vnuk (Adelaide University) and M. C. Benbow, R. A. Callen and S. R. Howles (Geological Survey of South Australia) who collected some of the fossiliferous boulders and kindly made them available for examination.

References

Abbott, P. L. & Peterson, G. L. (1978) Effects of abrasion durability on conglomerate clast populations: Examples from Cretaceous and Eocene conglomerates of the San Diego area, California. *J. sedim. Petrol.* **48**, 31-42.

Brown, H. Y. L. (1905) Report on geological explorations in the west and northwest of South Australia. *Parl. Pap. S. Aust.* 71.

Campbell, K. S. W., Rogers, P. A. & Benbow, M. C. (1977) Fossiliferous Lower Devonian boulders from the Cretaceous of South Australia. *Quart. geol. Notes, geol. Surv. S. Aust.* **62**, 9-13.

Carter, R. M. (1975) A discussion and classification of subaqueous mass-transport with particular application to grain-flow, slurry-flow, and fluxoturbidites. *Earth Sci. Rev.* **11**, 145-177.

Crowell, J. C. & Frakes, L. A. (1975) The late Palaeozoic glaciation. *In* K. S. W. Campbell (Ed.), "Gondwana Geology." pp. 313–331 (A.N.U. Press: Canberra).

Dun, W. S. (1898) Notes on the fauna of Devonian boulders occurring at the White Cliffs opal-fields. *Rec. geol. Surv. N.S.W.* **5**, 160-174.

FISHER, R. V. (1971) Features of coarse-grained, high-competence fluids and their deposits. *J. sedim. Petrol.* **41**, 916-927.

FORBES, B. G. (1966) The geology of the MARREE 1:250 000 map area. *Rept. Invest. geol. Surv. S. Aust.* 28.

HAMPTON, M. A. (1975) Competence of fine-grained debris flows. *J. sedim. Petrol.* **45**, 834-844.

JACK, R. L. (1915) The geology and prospects of the region to the south of the Musgrave Ranges, and the geology of the western portion of the Great Australian Artesian Basin. *Bull. geol. Surv. S. Aust.* 5.

LUDBROOK, N. H. (1966) Cretaceous biostratigraphy of the Great Artesian Basin in South Australia. *Ibid.* 40.

—— (1978) Australia. *In* "The Phanerozoic geology of the world." II. The Mesozoic, pp. 209–249. Elsevier.

MIDDLETON, G. V. & HAMPTON, M. A. (1973) Sediment gravity flows: Mechanics of flow and deposition. *In* G. V. Middleton & A. H. Bouma (Chairmen) "Turbidites and deep water sedimentation." Short course lecture notes; pp. 1–38 (Soc. econ. Paleont. Miner.: Los Angeles).

MORGAN, R. (1977) New dinoflagellate zones and a depositional model for the Great Australian Basin. *Quart. geol. Notes, geol. Surv. N.S.W.* **28**, 10-18.

PARKIN, L. W. (1956) Notes on the younger glacial remnants of northern South Australia. *Trans. R. Soc. S. Aust.* **79**, 148-151.

PITT, G. M. (1978) MURLOOCOPPIE map sheet, Geological Atlas of South Australia, 1:250 000 series, *Geol. Surv. S. Aust.*

RITCHIE, A. (1973) *Wuttagoonaspis* Gen. Nov., An Unusual Arthrodire from the Devonian of Western New South Wales, Australia. *Palaeontographica,* **143**, 58-72.

TALENT, J. A. (1965) The Silurian and Early Devonian Faunas of the Heathcote District, Victoria. *Mem. geol. Surv. Vict.* 26.

THOMSON, B. P. (1980) "Geological Map of South Australia." 1:1 000 000 Scale. *Geol. Surv. S. Aust.*

WOOLNOUGH, W. G. & DAVID, T. W. E. (1926) Cretaceous glaciation in South Australia. *Quart. J. geol. Soc. Lond.* **82**, 332-351.

WOPFNER, H. (1970) Permian palaeogeography and depositional environment of the Arckaringa Basin, South Australia. In "Second Gondwana Symposium," pp. 273–291. (Natal Witness Press: Pietermaritzburg).

——, FREYTAG, I. B. & HEATH, G. R. (1970) Basal Jurassic-Cretaceous rocks of western Great Artesian Basin, South Australia: Stratigraphy and Environment. *Bull. Am. Ass. Petrol. Geol.* **54**, 353-416.

—— & HEATH, G. R. (1963) New observations on the basal Creta-Jurassic Sandstone in the Mount Anna region, South Australia. *Aust. J. Sci.* **26**, 57-59.

YOUNG, G. C. (1974) Stratigraphic occurrence of some placoderm fishes in the Middle and Late Devonian *Newsl. Stratigr.* **3**, 243-261.

PROGAMOTAENIA NYBELIN (CESTODA: ANOPLOCEPHALIDAE): NEW SPECIES, REDESCRIPTIONS AND NEW HOST RECORDS

BY I. BEVERIDGE

Summary

The following species are described: Progamotaenia spearei sp. nov., from Thylogale stigmatica, distinguished by its small size, in having paired uteri, a fringed veleum and testes in two groups, and Progamotaenia johnsoni sp. nov. from Lagorchestis conspicillatus, which has an external seminal vesicle covered with glandular cells and testes distributed in two elongate groups. P. bancrofti (Johnston) and P. diaphana (Zschokke) are redescribed, and Lasiorhinus latifrons is considered to be the usual host of the latter species. P. zschokkei (Janicki) is reported for the first time from Macropus agilus, Onychogalea fraenata and O. unguifera; additional records of this species from Petrogale penicillata, Lagorchestes conspicillatus and Thylogale stigmatica are given.